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ESTIMATING POTENTIAL OUTPUT FOR THE U.S. ECONOMY IN A MODEL FRAMEWORK

A STUDY

PREPARED FOR THE USE OF THE

JOINT ECONOMIC COMMITTEE
CONGRESS OF THE UNITED STATES

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LETTERS OF TRANSMITTAL

November 29, 1976.

To the Members of the Joint Economic Committee:

Transmitted herewith is a study entitled "Estimating Potential Output for the U.S. Economy in a Model Framework." I believe Committee Members, other Members of Congress and other persons concerned with economic policy will find this study a useful aid to assessing the magnitude of the task of restoring full employment in the U.S. economy and to evaluating various policy proposals.

I would like to express my thanks to the authors of the study, Albert J. Eckstein and Dale M. Heien, and also to George M. von Furstenberg of the American Enterprise Institute and Ronald Kutcher of the Bureau of Labor Statistics, who reviewed the study at the Committee's request. The views expressed in the study are those of the authors and do not necessarily reflect the views of the Joint Economic Committee, individual members thereof, or members of the Committee staff.

Hubert H. Humphrey,
Chairman, Joint Economic Committee.

November 24, 1976.

Hon. Hubert H. Humphrey,
Chairman, Joint Economic Committee,
U.S. Congress, Washington, D.C.

Dear Mr. Chairman: Transmitted herewith is a study entitled "Estimating Potential Output for the U.S. Economy in a Model Framework" by Albert J. Eckstein and Dale M. Heien, together with a comment on the study by George M. von Furstenberg. This study utilizes an econometric model to measure the potential output which the U.S. economy could produce based on the availability not only of labor but of capital equipment and raw materials as well.

Accurate measurement of potential output is essential to an informed judgement as to what the appropriate levels of employment and unemployment are in our economy and how much economic growth is required to reach and sustain those levels. Basing the calculation of potential on supplies of capital and materials as well as labor helps us to determine whether there are supply constraints on production which might prohibit reaching full utilization of the labor force.

The study by Eckstein and Heien is an attempt to use a new and more comprehensive approach to the calculation of our economic potential. Its results indicate that potential output may be somewhat higher than the official estimates prepared by the Bureau of Labor

Statistics and the Council of Economic Advisers. The authors conclude that "the likelihood of supply restrictions and bottlenecks preventing the attainment of a 4.5 percent unemployment rate appear to be relatively small." Certainly, this is an encouraging conclusion. I hope this study, which is admittedly preliminary, will provoke further exploration of this vital question.

In addition to the published comment by Mr. von Furstenberg, this study has also been reviewed by Ronald Kutcher of the Bureau of Labor Statistics, whose comments were of assistance to the authors in making revisions in the study.

The views expressed in the study are those of the authors and do not necessarily represent the views of the members of the Joint Economic Committee or the committee staff.

John R. Stark,
Executive Director, Joint Economic Committee.

CONTENTS

ESTIMATING POTENTIAL OUTPUT FOR THE U.S. ECONOMY IN A MODEL FRAMEWORK

By **Albert J. Eckstein** *and* **Dale M. Heien**

I. INTRODUCTION

This study presents the results of initial research in developing an analytical framework for estimated potential output for the U.S. economy. The vehicle for this analysis is an econometric model which emphasizes the supply of labor and the production of output. The basic purpose of the paper is to demonstrate the advantages inherent in a formalistic model of potential output and to compare results obtained from the model with those presently in use. In so doing we hope to point out and disentangle some of the many separate, but interrelated issues surrounding potential GNP.

Foremost among these issues is the question of the level of unemployment which is chosen for the potential GNP computation. Empirical measures of potential GNP have specified potential output in terms of an arbitrarily defined level of utilization of the labor force, usually that associated with a four percent unemployment rate.[1] The historical precedence for such a definition has relied on analysis and judgments with respect to the adjustment processes within labor markets. The conventional wisdom has been that certain structural problems within labor markets must be solved before target rates below four percent can be achieved. Recently, there has been concern that changes in the age-sex-skill mix of the labor force have been such as to warrant a redefining of "full employment" at an unemployment rate higher than the traditional four percent. The evidence at hand does not demonstrate conclusively that new entrants into the labor force today have lower skill levels than in previous years. However, the structure of demand may have shifted in such a way that their average productivity is lower.[2] The question of the appropriate unemployment rate for potential output is probably, in the last analysis, not answerable in a precise manner. However, more analysis could be done on the level of frictional unemployment, the effects of legislated wage standards and the changing skills of the labor force. The question of the appropriate level of unemployment depends heavily on the trade-off between inflation and unemployment. This paper has little to say regarding the determination of the level of unemployment consistent with potential GNP. However, a methodology is given wherein parametric solutions (i.e., solutions dependent on various unemployment rates) for potential GNP can be compared. This comparison is a

[1] See, for example, Okun [24] and Denison [10] for discussion of the underlying concepts regarding potential output.

[2] See Perry [27] and Nordhaus [22]. It should be noted that in the approach taken by Denison [10], increased education of the labor force is assumed to augment the skill and productivity of the labor input over time, and thus add to potential output.

first step in assessing the cost of the inflation-output trade-off. The question of the relation between output and the price level, or the process of inflation itself, is still a matter of considerable professional debate.[3] Related questions, which also are not dealt with here, include the problem of proper monetary and fiscal policy to achieve full employment, policies for promoting maximum growth of output, and evaluation of the efficiency with which current resources are used.

While the economy has recently been forced to cope with new constraints in capital and material inputs, the goal of achieving full employment has been made more difficult by changes in demographic and institutional features of the labor force. Most persons born during the "baby boom" have now entered the labor force. Moreover, because of changes in education, attitudes toward women working, and real income growth, participation rates of the female labor force have increased considerably since 1960. Table 1 shows the changing distribution of the population by age group, along with participation rates for selected periods. As more workers enter the 25–44 age group, and as female participation continues to rise, achieving unemployment rates in the 4–4.5 percent range presents new difficulties.[4] By incorporating the behavior of the labor force, average weekly hours, wages and prices into a model with a production function dependent upon capital, labor and material inputs, it is possible to analyze the "cost" of closing any gap between actual and potential output in terms of wage and price effects. For reasons discussed below, in this initial modeling effort, the price determination process in all of the factor markets has not yet been developed. Hence, evaluation of target inflation rates along a defined potential output path is somewhat limited. However, as labor cost is the main component of overall cost and price movements, main effects are captured. An important aspect of the modeling effort is that it permits potential output at each point in time to vary in response to underlying relationships between endogenous and exogenous economic variables.[5] As will be seen in Chapter 3, this is particularly important with respect to the incorporation of higher rates of growth of the labor force during the 1970's.

TABLE 1.—DISTRIBUTION OF THE POPULATION BY AGE

[In percent]

Age group	1950	1960	1970	1980 (projected)	1990 (projected)
Below 16	28.3	32.6	31.1	25.4	25.8
16 to 24	13.3	12.1	15.0	16.7	12.8
25 to 44	30.0	26.1	23.6	27.8	31.9
45 to 64	20.3	20.0	20.5	19.4	18.2
65 and over	8.1	9.2	9.8	10.7	11.3

[3] See, for example, Okun [23].

[4] Awareness of such policy problems is evidenced in the testimony of John Dunlop [11] before the Subcommittee on Economic Growth of the Joint Economic Committee.

[5] A main criticism of the "official" (trend) method for computing potential GNP is that many factors which affect long-term output growth in the economy do not change smoothly. Relationships between factors of production in the current period, for example, may not correspond to those obtained in the base period from which the trend-type calculation is made. For further discussion of this point, see Denison [10].

PARTICIPATION RATES BY AGE AND SEX

Age group	1960	1970	1980	1990
Male:				
16 years and over	82.4	79.2	78.0	78.4
16 to 19 years	58.6	57.5	56.0	55.4
20 to 24 years	88.9	85.1	83.0	82.1
25 to 34 years	96.4	95.0	94.6	94.4
35 to 44 years	96.4	95.7	95.1	94.7
45 to 54 years	94.3	92.9	91.9	91.5
55 to 64 years	85.2	81.5	79.1	77.5
65 and over	32.2	25.8	21.2	19.3
Female:				
16 years and over	37.1	42.8	45.0	45.9
16 to 19 years	39.1	43.7	45.5	47.0
20 to 24 years	46.1	57.5	63.4	66.2
25 to 34 years	35.8	44.8	50.2	51.5
35 to 44 years	43.1	50.9	53.2	55.2
45 to 54 years	49.3	54.0	56.2	58.0
55 to 64 years	36.7	35.6	37.5	38.8
Both sexes 16 and over	59.2	60.3	60.8	61.5

Source: "Manpower Report of the President," 1975.

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II. MODEL DEVELOPMENT

The model developed here relates to the private nonfarm sector of the U.S. economy. This coverage is appropriate since most of the fluctuations in employment occur in that sector. Employment in the Government and farm sectors does not fluctuate greatly, and the forces determining the levels of output and employment in these sectors are less market-determined.[1] The core of the potential GNP model developed here consists of two relationships: the aggregate production function and the civilian labor force determination equations.

Traditional production function analysis has concentrated on the role of capital and labor in the determination of net output (net of intermediate production) of goods and services. Nonetheless, as witnessed recently, primary inputs (raw materials) do play a crucial role in the determination of levels of output.[2] Considering this factor, a production function was specified with manhours, capital stock times capacity utilization (to approximate the flow of services from the capital input), and raw materials as inputs. Technological change was specified as a constant rate of growth. The empirical form of the function selected was Cobb-Douglas, restricted to constant returns to scale. The estimated rate of technical change was 1.8 percent per year, and the elasticities of output with respect to labor, capital and raw material inputs were 64, 25 and 11 percent, respectively.[3]

Initially, we had planned to estimate the production function along the lines followed by Berndt and Wood [2]. Their framework considers gross output (value added plus material and energy inputs) in relation to capital, labor, energy and material inputs, and provides a consistent definition for proper estimation of the production function for a subsector of the economy. At higher levels of aggregation of the private economy, extending this framework becomes more difficult. Time series data for value added and gross output are available from BEA only for the manufacturing sector, which accounts for about 28 percent of total GNP. It is possible though not easy to construct a gross output measure for perhaps 40–45 percent of GNP. An alternative which was considered involved the use of data developed by Faucett [13], which was used by Berndt and Wood. These data relate to a highly aggregated input-output coverage of the economy, emphasizing energy input sectors, with a few basic demand sectors. Unfortunately, these data covered 1947–1971. Extending the series through 1974 is a task beyond the resources of this study.[4]

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[1] Government sector output is defined in terms of employment and constant dollars of compensation per employee of Government workers. By definition, the Government sector always fully utilizes its supply potential. Hence, variations in potential output in the overall economy do not depend upon Government sector output, and potential GNP is only different from potential private output by a scalar factor. Most variation in farm output is due to factors which affect supply, principally weather conditions. Farm policies which affect land utilization also affect farm output levels, but these are of less importance in the short-run than weather and decisions taken by farmers.

[2] This became evident even before the energy crisis, when the effects of Government price freezes on raw materials markets were observed in the summer of 1973.

[3] The empirical estimates are given in Appendix A.

[4] See Appendix B, Note 1.

This study has concentrated on a more complete specification of the input side of the production function. It is conventional practice to estimate production functions in terms of labor and capital inputs, but returns to land (as a primary factor of production) are usually omitted. Christensen and Jorgensen [5] have treated returns to land as a component of total capital in measuring real capital input in the economy. We have not split the capital stock into land and other types of capital, but have approximated this by the introduction of an input variable for primary materials, in addition to the usual capital stock variable representing structures and equipment.[5]

Items included in the raw materials input index used in the model have been constructed from the following data series: [6]

1. Domestic crude oil production (45.8)
2. Domestic natural gas production (14.9)
3. Domestic bituminous coal production (12.0)
4. Domestic copper ore production (1.3)
5. Domestic lead ore production (.5)
6. Domestic zinc ore production (1.8)
7. Domestic iron ore production (3.9)
8. Imported crude oil (5.4)
9. Imported natural gas (6.8)
10. Imported refined petroleum products (3.1)
11. Imported copper ore (1.2)
12. Imported iron ore (2.5)
13. Imported bauxite (.8)

The included items are obviously only a partial listing of possible choices. The energy items give a reasonably comprehensive coverage in that area, while the other items pertain to the most important metals utilized by the industrial sector of the economy.[7]

A demand relationship for manhours was specified as a function of output, the real wage, and the ratio of goods output to total output (MIX). The latter variable was introduced to handle problems associated with aggregating over goods sector and service sector employment. Average weekly hours are determined by the rate of change of output, the real wage,[8] and the MIX variable. The percentage change in money wages is determined by the inverse of the unemployment rate, the change in that rate, and the percentage change in current prices. Prices in turn are a function of unit labor costs and raw materials and energy prices. The capital stock is taken as exogenous—which for short-run (one year) computations of potential GNP seems plausible. Capacity utilization was treated as a function of the unemployment rate and a time trend. Raw material inputs were made to depend on the level of output, and were thus treated as a derived demand.[9]

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[5] See Appendix B, Note 2.

[6] The figures in parentheses indicate the percentage share of each item in the index based upon 1967 values.

[7] The main source of data for the raw materials is the Bureau of Mines' Minerals Yearbook. In some cases prices were given; in others, unit values are used, reflecting all the mix-shift anomalies inherent in that measure. All of the important prices are represented by unit value series. The various items were added together by construction of a constant dollar value series from the physicial quantity series. A price deflator for the overall series was developed by dividing the current and constant dollar estimates, and this price series was used as a variable in the price function for total output.

[8] The real wage variable can be interpreted to reflect both demand and supply factors. Other things equal, workers will desire more leisure as real wages rise. Firms, by contrast, can be expected to increase average hours as real wages fall.

[9] The own relative price did not prove to have significant statistical explanatory power. Also, unlike for labor input, factor market price determination in terms of a price-excess demand relationship, or factor demand-supply determination, was not successfully modeled. Since raw materials prices are highly dependent upon world market factors, these prices were taken as exogenous.

Other than the standard identities, the remaining relations of interest in the model are those for the determination of the male and female labor force participants. We found that female labor force participation could be estimated in a time series analysis using employment, real wages and the mix of output between goods and total output. The trend in real wages closely approximates the trend in female participation rates over most of the postwar period. It is doubtful if indexes reflecting other variables considered by Orcutt or Cohen [10] would provide statistically significant additions to the time series explanation of female participation rates.

Male participation rates have generally declined over most of the period since 1960, reflecting such factors as earlier retirement among those 55 years of age and over, and increased time spent in school by those in the younger age groups. Interestingly, participation by Negro and other races is lower than for whites, and has declined even more rapidly .This may reflect a number of factors such as migration to urban areas and the corresponding lack of match-up between skills and jobs, plus outright discrimination. These conditions no doubt explain the higher rate of "participation" of these groups in the Armed Forces. After some analysis, we found that for the male groupings most of the change in the aggregate male labor force could be explained by the differential movements of the various age groups in the population. That is, with constant (1960) participation rates, changes in population in the various age groups explained most of the variation in overall male labor force growth. We have not yet extended this hypothesis to the female labor force, but these results may suggest that participation rates are not changing in response to economic variables as much as some research suggests, but rather that much of the variation in labor force growth merely reflects changes in the age distribution of the population. In our judgment, research on this subject has not yet resolved the question of which are the most important determinants of labor force growth: the age distribution of the population, cyclical economic factors, or strictly demographic factors such as marriage, number of children, extent of education, and so forth.

In studying the behavior of average weekly hours, we found that inclusion of a variable reflecting the share of goods production in total production measurably improved the explanation of the cyclical behavior of average weekly hours. Perry [27] has also attempted to handle mix problems in the aggregate function for average hours by using an unemployment rate weighted by employment of different groups in the labor force as the cyclical variable.

Since the determination of average hours and the labor force are important to estimation of the endogenous unemployment rate, these functions are also indirectly important to the determination of the wage rate and price level within the model. We tried several simple hypotheses about the basic Phillips equation, but none was particu-

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[10] Early work by Orcutt, *et al*, [25] shows that labor force participation is related to a number of demographic-economic variables such as real wages, property-type income, debt and liquid asset positions, the age and number of children in a family, the level of education, and the structure of labor market demand in a particular locality. Cohen and others [9] have taken a similar approach, but also have investigated the "discouraged worker" hypothesis using cross-section data, and the general finding was that "discouragement" was greater in areas (labor markets) where the growth of employment was modest or nonexistent for long periods of time. This work supports the aggregate sort of time series analysis mostly attributed to Simler and Tella [28], in which female participation is hypothesized to be highly correlated with changes in effective employment demand.

larly rewarding. One idea was to approximate that a wage earner's perception of real wage changes due to price inflation is most influenced by frequently purchased items (such as food, gasoline or regularly paid utility bills), and that possibilities for money illusion are greatest with respect to infrequently purchased goods such as durable items. However, we found that a mere re-weighting of the CPI is not adequate as a means for approximating the frequency of purchase concept. Additional work would have to be done here to develop the correct data concept. Other factors which are important to aggregate wage behavior include an adequate incorporation of effects of collective bargaining cycles, and differences in the response of wages in the market-oriented segments of the labor market compared to Government sectors. With respect to the latter, some recent work by Hall [16] has shown that wages in the "nonentrepreneurial" sector (Government, communications, etc.) are unresponsive to cyclical forces, whereas wages in the "competitive" sector (trade and much of manufacturing) are responsive to changes in cyclical conditions. The implication he draws from this is that average wages in the competitive sector are higher than otherwise, since this sector has to compete with the nonentrepreneurial sector to retain its talented workers. He ascribes less of the non-cyclical wage push to the union-nonunion dichotomy in the labor force. However, there is some evidence that collective bargaining cycles do affect the change in wages on a period-to-period basis. A year of heavy collective bargaining with large first-year contract settlements may lead to changes in wage rates which cannot be fully explained by concurrent changes in cyclical conditions. The difficulty in introducing this sort of information into an annual time series wage equation has to do with the availability of data. BLS has published data on collective bargaining settlements covering 1,000 workers or more only since 1964, but it is a considerable task to construct a proxy from information in various issues of Current Wage Developments for prior years. It is our opinion that a considerable specification improvement can be made by incorporating some of these ideas into a more elaborate wage equation, and this would be one objective of further research.

It should be pointed out that the model is based upon annual time series, fitted from 1950 to 1974. There are several reasons for using annual data. First, data on energy and material inputs are not published by the Bureau of Mines on a quarterly basis. Similarly, capital stock figures would have to be interpolated from the annual figures. Since we wanted to focus upon structural relationships, and since the potential capacities of the economy can only be changed over the longer-run, we felt that an annual model would be appropriate. However, there are areas in which a quarterly model would provide some advantages. For example, in the adjustment of manhours to output, the lags may be less than one year. Similarly, average weekly hours may respond to changes in output in less than a one-year period.

III. MODEL SIMULATIONS AND POLICY IMPLICATIONS

This chapter briefly discusses some of the main results from the model. The measurement of potential output using the model is considered first. The essential economic behavior embodied in the model is discussed in terms of elasticities between principal endogenous and exogenous variables. Events of recent years are reviewed in a hypothetical way, and absorption of the labor force during the remainder of the 1970's is considered in light of energey supplies and growth and utilization of the capital stock.

Measurement of Potential Output

The definition of potential output is arbitrarily dependent upon the selection of utilization rates for the labor force, capital stock and material inputs. It is conventional to assume that the capital stock is the fixed input in the short-run, with labor and materials being relatively more variable inputs. It is also assumed that a four percent unemployment rate corresponds to "full employment." In order to "solve" the model for four percent unemployment, the equation defining unemployment was set equal to .04. Technically, the model at this point had n variables and n+1 equations. Hence one equation had to be deleted. The appropriate equation to drop was the labor (or more exactly, manhours) demand relation. Manhours is thus removed from the model and is required to be at a level consistent with a four percent unemployment rate. Capital services and raw material inputs are then determined at levels consistent with "four percent unemployment" output, with no regard to supply constraints. The remaining relations in the model, labor force, wages, prices, and average weekly hours are also jointly determined.

Table 2 presents figures on actual and potential output in the private nonfarm economy, 1951–1975, using four percent as the full employment unemployment rate. In comparison with "official" figures published in the Commerce Department's Business Conditions Digest, the model produces larger estimates of the GNP-gap. For example, in 1974 the model generated a gap between actual and potential output of $77.7 billion while the BCD estimate is $64.5 billion for a more inclusive definition of GNP. The corresponding percentage gaps for total GNP are 8.6 and 7.3 percent, respectively. This difference is mainly attributable to the fact that labor force growth in the model is considerably higher than that assumed in official estimates, particularly for recent years. Also, average weekly hours decline at a slightly slower rate in the model. For example, official estimates for the period since the fourth quarter of 1969 embody an annual growth rate of potential output of four percent, while the model produces a much higher average annual growth in the private nonfarm sector of 4.6 percent. Official estimates assume that the potential labor force will grow at an annual rate of 1.8

percent, while average hours will decline by .3 percent, and productivity growth will average 2.5 percent per annum. The model generates about the same average annual productivity growth rate since 1969, but average weekly hours decline by .28 percent. However, in the model, the average annual growth rate of the potential labor force is 2.4 percent over the 1969–1974 period, about the same as the actual growth rate of the labor force during this period, but well in excess of the 1.8 percent assumed in the official estimate.

TABLE 2.—MODELED POTENTIAL OUTPUT IN RELATION TO ACTUAL OUPTUT FOR THE PRIVATE NONFARM ECONOMY WITH THE "FULL EMPLOYMENT" UNEMPLOYMENT RATE EQUAL TO 4 PERCENT

[Dollar amounts in billions of 1958 dollars]

Year	Actual output (A)	Potential output (P)	Gap (P–A)	Percentage gap (P–A)/P
1951	$326.2	$323.9	−$2.3	−0.7
1952	334.2	332.8	−1.4	−.4
1953	351.1	350.5	−.6	−.2
1954	345.8	362.9	17.1	4.7
1955	376.3	377.5	1.2	.3
1956	384.0	390.3	6.3	1.6
1957	390.2	406.6	16.4	4.0
1958	384.4	421.5	37.1	8.8
1959	412.3	436.8	24.5	5.6
1960	422.1	453.2	31.1	6.9
1961	430.1	470.2	40.1	8.5
1962	460.8	486.4	25.6	5.3
1963	480.4	506.2	25.8	5.1
1964	509.7	527.2	17.5	3.3
1965	543.3	551.0	7.7	1.4
1966	581.1	574.3	−6.8	−1.2
1967	593.6	595.8	2.2	.4
1968	623.6	621.5	−2.1	−.3
1969	640.8	651.1	10.3	1.6
1970	639.6	680.2	40.6	6.0
1971	658.7	710.8	52.1	7.3
1972	705.7	744.2	38.5	5.2
1973	749.5	776.2	26.7	3.4
1974	729.5	807.2	77.7	9.6
1975	713.6	840.1	126.5	15.1

As it is customary to discuss the gap between actual and potential output in terms of total GNP, rather than private nonfarm GNP, corresponding figures are presented in Table 3 for comparison. As explained above, the path of potential output is taken as independent of the growth of farm and government sector outputs. Hence, computed percentage GNP gaps vary only with the comprehensiveness of the GNP concept employed.

TABLE 3.—COMPARISON OF THE GAP BETWEEN ACTUAL AND POTENTIAL OUTPUT FOR PRIVATE NONFARM AND TOTAL GNP MEASURES OF OUTPUT, 1951–75

[Dollar amounts in billions of 1958 dollars]

Year	Potential output			Percentage gap measures		
	Total GNP [2]	Private nonfarm GNP	Gap [1]	Total GNP	Private nonfarm GNP	Unemployment rate (UR)
1951	$381.1	$323.9	−$2.3	−0.6	−0.7	3.3
1952	393.6	332.8	−1.4	−.4	− 4	3.0
1953	412.2	350.5	−.6	−.1	−.2	2.9
1954	424.2	362.9	17.1	4.0	4.7	5.5
1955	439.1	377.5	1.2	.3	.3	4.4
1956	452.4	390.3	6.3	1.4	1.6	4.1
1957	468.8	406.6	16.4	3.5	4.0	4.3
1958	484.4	421.5	37.1	7.7	8.8	6.8
1959	500.4	436.8	24.5	4.9	5.6	5.5
1960	518.8	453.2	31.1	6.0	6.9	5.5
1961	537.2	470.2	40.1	7.5	8.5	6.7
1962	555.4	486.4	25.6	4.6	5.3	5.5
1963	576.8	506.2	25.8	4.5	5.1	5.7
1964	598.6	527.2	17.5	2.9	3.3	5.2
1965	625.5	551.0	7.7	1.2	1.4	4.5
1966	651.3	574.3	−6.8	−1.0	−1.2	3.8
1967	677.3	595.8	2.2	.3	.4	3.8
1968	704.6	621.5	−2.1	−.3	−.3	3.6
1969	735.9	651.1	10.3	1.4	1.6	3.5
1970	765.7	680.2	40.6	5.3	6.0	4.9
1971	797.9	710.8	52.1	6.5	7.3	5.9
1972	830.9	744.2	38.5	4.6	5.2	5.6
1973	865.9	776.2	26.7	3.1	3.4	4.9
1974	898.8	807.2	77.7	8.6	9.6	5.6
1975	[3] 945.7	840.1	126.5	13.4	15.1	8.5

[1] From table 2, col. 3.
[2] Private nonfarm potential output (table 2) plus farm and Government sector output.
[3] Preliminary estimate.

Simulation with the Model

Table 4 presents a set of elasticities derived from the model. For percentage changes in exogenous variables changes in key endogenous variables can be calculated. Most of the figures in the table are self-explanatory. It may be noted that changes in the capital stock, material inputs or the mix of goods output relative to total output have no impact upon the male labor force. This follows from the fact that the male labor force responds only to changes in the male population and a time trend. The female labor force, on the other hand, is responsive to a number of variables generated within the model. Similarly, because a price-quantity relationship has not been established for material inputs, the level of material inputs does not affect prices. Shifts in the output mix deserve explanation. Changes in the ratio of goods production to total production (thus, production of goods versus services) have a powerful effect through determination of the demand for inputs. Relatively more goods production reduces employment (presumably reflecting capital for labor substitution, and/or higher capital-labor coefficients associated with goods production), and the growth of the female labor force. Negative effects here are, paradoxically, large enough to generate a reduction in total unemployment and the unemployment rate. This suggests that a larger share of service sector production will induce more female participation in the labor force and raise total employment, but will simultaneously raise the unemployment rate.

TABLE 4.—ELASTICITIES[1] DERIVED FROM THE MODEL

Endogenous variables[2]	Exogenous variables[2]										
	Capital stock	Materials input		Output mix	Male population by age groups						
		Quantity	Price		16 to 17	18 to 19	20 to 24	25 to 34	35 to 44	45 to 54	55 to 64
Average weekly hours	0.02	0.01	0.01	0.19	0	0	0.01	0.02	0.01	0.01	0.01
Real output	.37	.16	.02	.09	0	0	.01	.02	.01	.01	.01
Total employment	.14	.06	.01	−.04	0	0	0	.01	.01	.01	0
Total man-hours	.19	.08	.02	.14	0	.01	.02	.03	.02	.02	.02
Wage rate	.22	.08	.14	.13	−.04	−.05	−.15	−.26	−.21	−.21	−.16
Civilian labor force	.03	.02	0	−.08	.02	.02	.07	.12	.09	.10	.07
Male	0	0	0	0	.03	.04	.11	.20	.15	.16	.11
Female	.09	.04	.01	−.19	0	0	0	.01	0	0	0
Total unemployment	−2.49	−1.10	−.48	−.93	.38	.54	1.57	2.92	2.25	2.33	1.68
Unemployment rate	−2.52	−1.11	−.49	−.86	.36	.51	1.50	2.77	2.14	2.21	1.60
Price level	.03	0	.18	.13	−.03	−.04	−.10	−.17	−.14	−.14	−.11

[1] Measured as the percent change in the engdoenous variable given a 1-percent change in the exogenous variable.
[2] Variables are defined in app. A.

The gap between actual and potential output has been substantial since 1970, as shown in Table 2. While a good part of this may be attributable to demand management policies, there have been important changes in the supply capabilities of the economy which have become a concern only recently. Labor force participation and growth have both increased. Domestic crude oil production peaked by 1972, and natural gas production slowed, partly in response to regulation of prices in that sector. Energy imports rose dramatically after 1970, until the extraordinary price increases and export policies imposed in 1974 dramatically altered both demand and supply. These factors underlie the movements of total energy supply and its components as shown in Table 5. During this period, an increasing proportion of capital investment was allocated to pollution abatement activities, as opposed to meeting requirements for capacity expansion or replacement. Investment to meet pollution requirements may have introduced some anomalies in the measurement of effective capital stock utilization. Simple addition of investment for pollution abatement to the overall capital stock may overstate the growth of the productive capital stock, and thereby understate actual capacity utilization. For example, in 1973 the capacity utilization rate was 83 percent, while in the peak year of 1966, it was 91.9 percent. In both years, however, the ratio of goods production to total output was approximately the same, there is no reason to think that capital-output ratios have fallen significantly over so short a period.

TABLE 5.—ENERGY INPUTS IN THE U.S. ECONOMY SINCE 1967[1]

Year	Crude petroleum		Refined petroleum imports	Natural gas		Bituminous coal	Total energy
	Domestic	Imported		Domestic	Imported		
Indexes, 1967 equals 100:							
1967	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1968	104.7	114.6	110.3	105.8	115.5	93.3	104.4
1969	105.1	124.8	124.7	113.6	128.8	95.6	108.1
1970	110.2	117.2	148.8	121.8	145.5	104.2	114.9
1971	107.4	148.8	159.3	124.5	165.6	94.5	115.4
1972	107.6	196.8	179.8	123.6	180.7	108.4	121.9
1973	104.9	315.0	198.4	125.9	180.0	100.5	128.5
1974	100.7	330.6	166.3	119.8	171.4	102.3	123.9
Percentage changes:							
1968	4.7	14.6	10.3	5.8	15.5	−6.7	4.4
1969	.4	8.9	13.0	7.4	11.5	2.5	3.5
1970	5.8	−6.0	19.4	7.2	12.9	9.0	6.3
1971	−2.5	26.9	7.1	2.2	13.9	−9.3	.5
1972	.1	32.3	12.8	−.7	9.1	14.7	5.6
1973	−2.5	60.0	10.4	1.9	−.4	−7.3	5.4
1974	−4.0	4.9	−16.2	−4.9	−4.8	1.8	−3.6

[1] Represent those inputs embodied in the model. Indexes are based on constant dollar figures. Basic data are from the U.S. Bureau of Mines.

We have attempted to use the model to evaluate the 1970–1974 period in terms of changes in supply variables. It is of some interest to determine how much more of the growing labor force could have been absorbed during these years if "normal" supply conditions had prevailed, and demand management had been reasonably astute. The assumptions made below might have looked reasonable if planning ahead, say, from 1970:

1. Energy inputs grow at 5.5 percent per annum, reflecting deregulation of natural gas prices and demand characteristics incorporating

higher fuel consumption by automobiles imposed by pollution standards and heavier weights.

2. Energy prices rise by 7.5 percent in each year, which is approximately the weighted average rate of increase for the 1970–1973 period. In the model, this converts into a 6.5 percent increase in the material input price variable.

3. To offset requirements for pollution abatement, the capital stock expands by an additional 5 percent in each year. This is a modest change which disregards any changes in investment demand stemming from the devaluation of the dollar.

4. Capacity utilization is mainained at the 1973 level of 83 percent in all years. With the growth in the capital stock, this produces a total growth in services from the capital stock of 6 percent for each year.

5. In conjunction with a higher rate of energy and capital stock utilization, the share of goods output in total production is higher, on average, by 1.4 percent (that is, all years are set at the 1973 value for this variable).

Using the appropriate elasticities from Table 4, the following results are obtained:

[In percent]

	Impacts due to changes in [1]—				Total impact
	K	QRM	PRM	MIX	
Average weekly hours	0.12	0.05	0.07	0.27	0.51
Real output	2.22	.80	.13	.13	3.28
Employment	.84	.30	.07	−.06	1.15
Total man-hours	1.14	.40	.13	.20	1.87
Wage rate	1.32	.40	.91	.18	2.81
Total labor force	.18	.10	.02	−.11	.19
Unemployment rate	−15.12	−5.55	−3.18	−1.20	−25.05
Price level	.18	0	1.17	.18	1.53

[1] Abbreviations: K equals capital, QRM equals materials, PRM equals price of materials, and MIX equals ratio, goods output to total output.

These results indicate that the unemployment rate would have been 1.2 percentage points lower—i.e., instead of an annual average rate of 5.4 percent during these years, the unemployment rate would have been 4.2 percent. Actual output would have been 3.3 percent higher in each year, and the average gap between actual and potential output would have been reduced from $45.1 billion per year to $34.2 billion. The gap as a percent of potential output would have averaged 4.5 percent instead of 6.6 percent. On average, there would have been 1.0 million more jobs in the economy each year between 1970 and 1974.

Under the above assumptions, the overall price level rises by 1.53 percent per annum. Because assumption (2) approximates the actual energy price change which occurred, the net increment to the price level due to differences between assumed and actual values for other variables is only .36 percent. This net price increase is consistent with the implied increment to the annual growth of productivity and real wages of 1.4 percent. Private nonfarm real wages actually grew at an annual rate of only 1.1 percent, on average, during 1970-74. Consequently, achievement of a somewhat higher rate of growth and utilization of the economy's resources, as under these assumptions, implies a rather substantial increment to the growth in real wages without significant supply-side price inflation.

The model can also be used to trace out the direct impact of the "energy crisis" of 1974. Energy prices increased 111 percent from 1973 to 1974, while the quantity of inputs declined by 3.6 percent. The decline in energy inputs increased the unemployment rate by two-tenths, and the price increase contributed 15.6 percent to the overall price level, and through the wage-price feedback, 8.6 percent to the wage level. While the model does not incorporate indirect effects of these changes upon utilization of the capital stock and the composition of total output, it is fair to assume that a portion of reductions here (those not attributable to tightened monetary policy in response to the price effects) are due to changes in the price and quantity of energy available. Goods production as a share of total output fell by 1.1 percent, and capacity utilization fell from 83 to 79 percent. Even though the real capital stock grew by an estimated four percent in 1974, the decline in capacity utilization reduced total capital services by one percent from 1973 levels. These changes would add an additional one to two-tenths to the unemployment rate. Thus, the model would suggest that about four of the seven-tenths increase in the unemployment rate between 1973 and 1974 was attributable to the decline in energy inputs and their higher price.

In order to consider the impact of future trends in energy inputs during the remainder of the 1970's, we have used the FEA's *Project Independence* study. Growth patterns in crude oil production are based upon the maintenance of an $11 per barrel price in constant (1974) dollars through 1985. Natural gas prices are decontrolled, and are assumed to rise to an average of $1 per MCF in 1974 prices. Coal is assumed to have a price of $15 per ton in constant prices. Nominal prices for oil are assumed to rise at an annual rate of 3.5 percent. Exact assumptions are shown below.

[In percent]

	Real growth	Price increase
Domestic crude oil	2.8	3.5
Imported crude oil	2.0	3.5
Imported refined products	0.0	3.5
Domestic natural gas	2.0	8.5
Imported natural gas	0.0	8.5
Domestic coal	4.0	8.5

The weighted impact of the above assumptions yield a 4.3 percent increase in material input prices, and a 2.1 percent increase in the quantity. It may be noted that the latter value is considerably lower than the 4.4 percent increase in energy inputs which prevailed during 1963–1973. These assumptions about energy inputs are assumed to apply through 1980, and can thus be interfaced with population projections for 1980. With assumptions about the composition of output and growth in the capital stock, the extent of unemployment imposed by plausible supply conditions can be evaluated.

The availability and price of imported energy is an important unknown with respect to future supplies. Not only is imported energy subject to policy changes of foreign governments, but under a regime of flexible exchange rates, it is subject to fluctuations in the exchange value of the dollar. On the basis of recent history, fluctuations in the

weighted exchange rate between the dollar and currencies of those countries supply the U.S. economy with raw material inputs easily could be in the range of plus or minus 20 percent. To stimulate the impact of a change in the exchange rate, the following is assumed:

1. The short-run price elasticity of import demand for raw material products is low—on the order of 0 to −.5—reflecting the fact that substitution possibilities are limited in the short-run.

2. In 1974, the share of imports in the total materials input in the model was about 28 percent. Although energy imports may decline in terms of growth rates in future years, it is assumed that a rising dependence upon other imported materials will continue. Hence, the share of imports in total materials has been kept at 1974 values, rather than reduced to pre-1970 levels.

If the price elasticity of demand for imports of raw materials is on the order of −0.5, a 20 percent change in the exchange rate (plus or minus) implies a 10 percent change (plus or minus) in the quantity of imports, and a 2.8 percent change in the materials input variable within the model. This produces a four-tenths of one percent decline in output, a two-tenths of one percent decline in employment, and a three percent rise in the unemployment rate, assuming there are no domestic substitutes for these imported inputs. The overall price level would be higher by about one percent.

Using the estimated relationship for the male labor force from the model and the population projection figures from Table 6, we estimate the male labor force in 1980 to be 63.126 million persons. This figure is 14.4 percent above the 1974 value of 55.190 million, and slightly greater than the 1980 projection of 62.590 million given in the 1975 Manpower Report. Using a similar methodology for the female labor force gives a 1980 figure of 40.970 million persons, as opposed to the Manpower Report figure of 39.219 million. The Manpower Report projection relies upon declines in the participation rate in certain important age groups of the male population, while our projection is based upon the model equation. Our figure implies a growth in the female labor force of 14.4 percent. Hence, the growth in the civilian labor force from 1974 to 1980 will be 14.4 percent, resulting in a labor force of 104.1 million. Using our estimated production function and allowing capital and technological change to grow at their historical rates of 4.05 percent and 1.8 percent, and allowing materials to grow at 2.1 percent,[1] it will be necessary for private non-farm output to grow at an annual rate of 4.62 percent in order to achieve a reduction in the unemployment rate from 5.6 percent in 1974 to 4.0 percent in 1980.[2] Historically, the average annual growth rate of output has been 3.5 percent. In order to simply absorb the projected labor force growth and maintain the unemployment rate at the 1974 figure of 5.6 percent, output will have to grow at an annual rate of 4.44 percent, still far above the historical pattern.

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[1] Also assumed is a constancy in the average weekly hours.

[2] Since output declined by 2.2 percent in 1975 from its 1974 level, computing from 1975 indicates that output would have to grow at a compound annual rate of 6 percent through 1980. If the economy were to grow by 7 percent in both 1976 and 1977, it would have to achieve an annual growth rate of 5.4 percent for the years 1977–1980 to reduce the unemployment rate to four percent by 1980.

TABLE 6.—GROWTH RATES IN THE MALE POPULATION BY AGE GROUP,[1] 1974-90

Age group (years)	Percent change in population	
	1974-80	1974-90
16 to 17	−3.0	−24.3
18 to 19	4.4	−11.5
20 to 24	11.5	−4.1
25 to 34	21.6	38.0
35 to 44	12.5	60.8
45 to 54	−4.4	6.5
55 to 64	7.7	5.5
65 and over	10.6	28.5
All groups	9.4	19.5

[1] Based upon series II data of the "Current Population Reports," U.S. Bureau of Census.

Policy Implications

The foregoing analysis has led us to the following conclusions concerning potential GNP in the U.S. economy. First, present levels of GNP are substantially below potential levels ($200 billion, measured in current dollars). In the present context, the likelihood of supply restrictions and bottlenecks preventing the attainment of a 4.5 percent unemployment rate appear to be relatively small.[3] This statement is conditioned upon the assumption that there will be no arbitrary disruption of energy supplies or radical changes in their prices. If this can be assumed, much of the present gap between actual and potential output can be viewed as a demand management problem.

Views differ as to the causes of the current slump. There is evidence, however, that the restrictive monetary actions taken in 1974 in an effort to stem inflationary forces in the economy were based upon a misreading of the causes of that inflation and the appropriateness of monetary policy for dealing with the problem. Most of the inflation which occurred is attributable to radically higher fuel and food prices, induced largely by changes in supply conditions. Higher energy prices had a particularly large impact upon automobile demand. Consumers' confidence was badly shaken by the oil embargo which made the availability of fuel highly uncertain. The rapid increase in gasoline prices coupled with lower fuel mileage due to Government-mandated pollution equipment, made new automobiles even less attractive. Radically higher prices of new cars reflecting added costs associated with safety and pollution equipment and higher production costs (due in part to higher energy costs) also served to severely dampen consumer demand. The construction sector was badly victimized by the higher interest rates associated with restrictive monetary policy. Also, a good part of the over-accumulation of inventories in 1974 was in response to supply disruptions in basic materials.

The following reduction in inventories may, however, have been more in response to monetary factors affecting both demand for output and the cost of holding inventories. In addition to these events, the many disruptions and uncertainties for both consumers and pro-

[3] For example, the unemployment rate for experienced wage and salary workers climbed from 4.5 percent in 1973 to 8.2 percent in 1975, but has declined to 7.4 percent in early 1976. Unemployment rates for blacks, teenagers and part-time workers have risen more sharply and may be more difficult to reduce through aggregate demand policies than previously. However, experienced workers presently unemployed comprise over three-fourths of total unemployment, and the employment for these workers is generally responsive to aggregate demand conditions.

ducers which accompanied the period of price controls significantly eroded confidence and upset expectations.

The above statements do not imply that demand management policies needed to return the economy to full employment are easily designed.[4] However, the downward trend in the unemployment rate achieved during 1973, which produced a 4.5 percent rate in October of that year, would appear to be a feasible goal and attainable through usual monetary and fiscal policy measures. Should supply-induced inflationary forces reappear as in 1973–1974, restrictive monetary policy will not serve to solve those problems—reduced output and employment will work the other way. Lost opportunities for capital accumulation imply a lower growth rate in trend productivity, and other things equal, higher rates of inflation over the longer run.

Although in our judgment most of the present weakness in the economy reflects deficient aggregate demand, we are cognizant that supply side conditions are more relevant than in the past. For example, in 1973–1974, there were important capacity constraints in some sectors of the economy (steel, paper, petrochemicals, and gasoline refining). In some cases these deficiencies reflected a history of inadequate domestic investment due to prior over-valuation of the dollar. In other cases, safety and pollution investment comprised a significant share of total investment. At the present time, however, there is little reason to expect that capacity problems in these sectors would lead to sectoral bottlenecks or outsized price increases under conditions of substantially greater stimulus to aggregate demand than contemplated by the Administration for 1976.[5]

Recommendations for Further Research

A conclusion we draw which pertains more directly to the results of this study concerns the *growth* of potential output over time. Even considering all of the disruptions in supply which occurred in the 1973–1974 period, most of the gap between actual and potential output is due to the deficient demand, rather than a significant alteration of the potential path itself. The above analysis indicated the substantial growth which can be expected in the labor force over the next few years, and on into the 1990's. What is needed at this point for analyzing the employment issue, the energy question, and (thus) the "capital shortage" issue, is a framework for analyzing the growth potential of the U.S. economy. Input-output growth models (such as the BLS model) or the approach of Denison do not properly address the dynamics of the growth process. And, in terms of recent experiences, existing models do not adequately incorporate price behavior—hence, changes in relative prices of both inputs and outputs, which

[4] For example, there appear to be increasingly difficult structural problems of aligning labor demands with age-skill characteristics of the labor force in central city areas of large metropolitan areas.

[5] With low worldwide stocks of grains, poor harvests could again set off a rapid inflation in food prices. If combined with large fuel price increases, inflationary forces as existed during the 1972–74 period could again appear. If the monetary authority does not want to "validate" supply-induced inflation, lower levels of output and employment are implied. With supply inflation, it may be necessary to raise target inflation rates in order to keep other resources in the economy fully utilized.

are most important, are largely ignored.[6] Present macro-models used for short-run forecasting are largely demand-oriented, and deficient in the portrayal of price behavior. The model developed in this study is also deficient in terms of portraying price behavior since our model ignores the determination of output from the demand side.[7]

To successfully analyze the supply side of the economy, a model is required which fully treats all inputs. Hence, labor supply by sex, age and race would be an important component to incorporate in the model. Equally important would be development of labor demand relationships for the above categories, so that long-term structural problems such as black and teenage unemployment, and effects of minimum wage policies could be studied. Likewise, a sector would be developed to explain the demand and supply of capital. This would require expansion of the model to include income determination in order to link saving and investment behavior to the growth of the capital stock. Effects of changes in policy variables such as tax rates and tax credits, depreciation policies, etc., upon output and employment demand could then be studied.[8] To adequately trade the effects of energy inputs and other primary inputs through the economy requires a disaggregation of the economy into subsectors. An initial model might include durable and nondurable manufacturing, wholesale and retail trade, agriculture, construction, transportation, services and government. Only through some degree of disaggregation accompanied by the specification of production functions with capital, labor, energy and intermediate inputs can relative price changes be adequately modeled, Such disaggregation would also permit examination of various hypotheses with respect to sector differences in wage adjustment (such as Hall's hypothesis about wage adjustment in the nonentrepreneurial versus competitive market sectors).

It is clear that a main reason why aggregate models have not produced meaningful projections in recent years is the presumption of constant relative price relationships between subsectors. The "washing out" of these effects in the aggregate did not hold under conditions of currency devaluation and radical changes in energy prices. Changes in relative prices have important consequences for the composition of output and, hence, employment demand. A fully detailed production function in a multi-sector model including sectoral wage and price relationships could be used to examine how much the growth potential of the economy responds to changes in relative prices and distortions in structure of relative prices (both between sectors and between

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[6] Some recent work by Berndt and Wood [2], covering the manufacturing sector of the economy, considers the role of energy and material inputs in production in terms of their relative prices. Their results show that capital and energy are complements, while capital and labor, energy and labor, and energy and other material inputs are substitutes. For example, a decontrol of energy prices will reduce capital and energy-intensiveness in production, and raise labor-intensiveness, which suggests that freeing energy prices may promote greater employment in the longer run. On the other hand, expanding the investment tax credit will raise the demand for capital, and raise the demand for energy (since they are complements). The final employment effect depends on whether the substitution or expansion impact of the tax credit dominates

[7] In addition, no attempt was made to explicitly link the behavior of farm prices to prices in the nonfarm sector. The impact of farm prices on nonfarm prices since 1972 has been particularly important and may remain so in years to come.

[8] These effects are not obvious. For example, some recent work by Coen [8] shows that the effects of tax policies on investment and employment are crucially dependent upon the price determination process in the economy. The effect of the credit on output and employment expansion as opposed to capital for labor substitution depends upon the extent to which changes in the cost of capital are passed on to product prices or retained as profits.

factor inputs for a particular sector). Distortions in the wage and price structure could be evaluated in terms of Government policies (minimum wage laws, wage-price controls, tax credits, depreciation rulings, etc.) and other institutional arrangements which have contributed to the existing market structure.

The magnitude of work involved in developing a multi-sectoral model in which input and output price determination is more adequately portrayed is large. As usual, much of the work is in the development of appropriate data series to match the economic concepts to be modeled. Consequently, such model development ought to be carried out in cooperation with appropriate Government agencies having responsibility for the construction of basic economic data.

Appendix A. EMPIRICAL EQUATIONS OF THE MODEL

I. Estimated Equations[1]

(1) Labor Force Females

$$(LFF/FP160)=\underset{(1.17)}{.0658}+\underset{\substack{(3.58)\\ .70}}{.388}(TE/P20\text{–}65)+\underset{\substack{(9.05)\\ .32}}{.053}(PNFWR/PNFPI)_{-1}$$

$$-\underset{\substack{(1.84)\\ .19}}{.131}\,\mathrm{MIX}$$

$$\bar{R}^2=.992 \qquad \text{S.E.E.}=.0033 \qquad \text{D.W.}=1.00$$

(2) Labor Force Males

$$LFM=.1008\mathrm{E}{+}08+\underset{\substack{(57.73)\\ .80}}{.7935}\cdot\mathrm{SUM}-\underset{\substack{(1.33)\\ .01}}{98952.}\ln\mathrm{TIME}$$

$$\bar{R}^2=.998 \qquad \text{S.E.E.}=.1656\mathrm{E}{+}06 \qquad \text{D.W.}=.53$$

(3) Quantity of Raw Materials

$$QRM=.3501\mathrm{E}{+}10+\underset{\substack{(34.57)\\ .80}}{.0285}\cdot QGPNP$$

$$\bar{R}^2=.981 \qquad \text{S.E.E.}=.5639\mathrm{E}{+}09 \qquad \text{D.W.}=1.20$$

(4) Quantity of Gross Private Nonfarm Product

$$\ln(QGPNP/PNFMH)=1.2315+\underset{(4.7)}{.2508}\ln(KS\cdot CU/PNFMH)$$

$$+\underset{(1.4)}{.1109}\,\ln(QRM/PNFMH)+\underset{(13.2)}{.0176}\cdot\mathrm{TIME}$$

$$\bar{R}^2=.995 \qquad \text{S.E.E.}=.013 \qquad \text{D.W.}=1.28$$

(5) Private Nonfarm Manhours

$$PNFMH=.6575\mathrm{E}{+}11+\underset{\substack{(7.12)\\ .47}}{.1042}\,QGPNP-\underset{\substack{(1.81)\\ .10}}{(.7769\mathrm{E}{+}10)}$$

$$\cdot(PNFWR/PNFPI)+\underset{\substack{(1.03)\\ .10}}{(.1965\mathrm{E}{+}11)}\,\mathrm{MIX}$$

$$\bar{R}^2=.994 \qquad \text{S.E.E.}=.87\mathrm{E}{+}09 \qquad \text{D.W.}=1.91$$

(6) Private Nonfarm Wage Rate

$$\dot{PNFWR}=.0043+\underset{\substack{(3.64)\\ .63}}{.00165}\,UR^{-1}-\underset{\substack{(3.64)\\ .001}}{.8116}\,(UR-UR_{-1})$$

$$+\underset{\substack{(5.22)\\ .29}}{.5638}\cdot\dot{PNFPI}$$

$$\bar{R}^2=.77 \qquad \text{S.E.E.}=.0109 \qquad \text{D.W.}=1.81$$

(7) Private Nonfarm Price Index

$$PNFPI=.219+\underset{\substack{(19.7)\\ .69}}{1.27}\,ULC+\underset{\substack{(5.5)\\ .045}}{.0466}\cdot PRM+\underset{\substack{(6.2)\\ .064}}{.0054}\cdot\mathrm{TIME}$$

$$\bar{R}^2=.998 \qquad \text{S.E.E.}=.0087 \qquad \text{D.W.}=1.47$$

[1] The figures below the regression coefficients in parenthesis are the t-values. The numbers below the t-values are the elasticities (at the means). A dot above the symbol indicates percent change.

(8) Average Weekly Hours

$$AWH = 36.29 + 4.66\,QGPNP - 1.86\,(PNFWR/PNFPI) + 11.53 \cdot MIX$$
$$\begin{array}{ccc} (3.5) & (18.7) & (2.6) \\ .005 & .2 & .17 \end{array}$$
$$\bar{R}^2 = .948 \qquad S.E.E. = .266 \qquad D.W. = .89$$

II. Identities

(9) Civilian Labor Force

$$CLF = LFF + LFM$$

(10) Unemployment

$$U = CLF - TE$$

(11) Total Employment

$$TE = (PNFMH/AWH)\ 52.0 + FE + SLE + FRE$$

(12) Unemployment Rate

$$UR = U/CLF$$

III. List of Variables

*AWH: Average weekly hours (BLS)
*CLF: Civilian labor force (BLS)
CU: Capacity utilization (FRB)
FE: Federal government employment (BLS)
FP160: Female population 16 and over (CENSUS)
FRE: Farm employment (BLS)
KS: Capital stock (BEA)
*LFF: Labor force female (BLS)
*LFM: Labor force male (BLS)
MIX: Ratio of goods output to total output (BEA)
MP16–17: Male population 16–17 (CENSUS)
MP18–19: Male population 18–19 (CENSUS)
MP20–24: Male population 20–24 (CENSUS)
MP25–34: Male population 25–34 (CENSUS)
MP35–44: Male population 35–44 (CENSUS)
MP45–54: Male population 45–54 (CENSUS)
MP55–64: Male population 55–64 (CENSUS)
MP65+ : Male population 65+ (CENSUS)
PC: Price of bituminous coal (BOM)
PCO: Price of crude oil (BOM)
PCOP: Price of copper (BOM)
PIO: Price of iron ore (BOM)
PL: Price of lead (BOM)
PMB: Price of imported bauxite (BOM)
PMCO: Price of imported crude oil (BOM)
PMCU: Price of imported copper ore (BOM)
PMIO: Price of imported iron ore (BOM)
PMNG: Price of imported natural gas (BOM)
PMRP: Price of imported refined petroleum (BOM)
*PNFPI: Private nonfarm price index (BEA)
*PNFWR: Private nonfarm wage rate (BEA)
PNG: Price of natural gas (BOM)
PNFMH: Private nonfarm manhours (BLS)
PRM: Price of raw materials=VRM/QRM
P20–65: Female population 16 and over (CENSUS)
PZ: Price of zinc (BOM)
QC: Quantity of bituminous coal produced domestically (BOM)
QCO: Quantity of crude oil produced domestically (BOM)
QCOP: Quantity of copper produced domestically (BOM)
*QGPNP: Quantity of gross private nonfarm product (BEA)
QIO: Quantity of iron ore produced domestically (BOM)
QL: Quantity of lead produced domestically (BOM)
QMB: Quantity of bauxite imported (BOM)

* Denotes endogenous variable.

QMCO: Quantity of crude oil imported (BOM)
QMCU: Quantity of copper ore imported (BOM)
QMIO: Quantity of iron ore imported (BOM)
QMNG: Quantity of natural gas imported (BOM)
QMRP: Quantity of imported refined petroleum (BOM)
QNG: Quantity of natural gas produced domestically (BOM)
*QRM:

$$\text{Quantity of raw materials} = PZ_{67}*QZ+PL_{67}*QL+PC_{67}*QC \\ +PCO_{67}*QCO+PNG_{67}*QNG+PMIO_{67}*QMIO+PMNG_{67}*QMNG \\ +PMRP_{67}*QMRP+PMB_{67}+QMB+PMCO_{67}*QMCO+PIO_{67}*QIO \\ +PCOP_{67}QCOP+PMCU_{67}*QMCU$$

QZ: Quantity of zincs produced domestically (BOM)
SUM:

$$.426*MP16\text{–}17+.667*MP18\text{–}19+.869MP20\text{–}24+.972*MP25\text{–}34 \\ +.976*MP35\text{–}44+.56*MP45\text{–}54+.862*MP55\text{–}69+.303*MP65+$$

*TE: Total employment (BLS)
TIME: 1950=1.0, 1951=2.0, etc.
U: Unemployment (BLS)
ULC: PNFWR*PNFMH/QGPNP—Unit labor costs
UR: Unemployment rate (BLS)
VRM:

$$\text{Value of raw materials} = PZ*QZ+PL*QL+PC*QC+PCO+QCO \\ +PNG*QNG+PMIO*QMIO+PMNG*QMNG+PMRP*QMRP+PMB*QMB \\ +PMCO*QMCO+PIO*QIO+PCOP*QCOP+PMCU*QMCU$$

* Denotes endogenous variable.

Appendix B. TECHNICAL NOTES

1. The Faucett data include an input-output flow table for each year. However, for many sectors of the economy, time series data on gross output are not statistically very "rich," since the figures are derived by moving a base period ratio of gross output to value added by value added figures for particular years. True measures of output for non-industrial sectors of the economy are also often not available, and deflated income measures are not always reliable proxies. It is also the case, for highly aggregated subsectors of the economy, as treated by Berndt and Wood, that intra-sectoral shipments of materials and energy inputs introduce problems in double-counting; if not treated explicitly, true relationships between exogenous inputs and total supply can be obscured.

2. Imports have also been treated somewhat differently in the definition of input used here. In the national income accounts, net exports equal gross exports less gross imports, a definition compatible with net income and product concepts. This treatment does not differentiate between imports which enter (and affect) intermediate production from those which enter final demand categories. Excepting years in which input-output tables have been developed, time series data have not been developed in which imports are distinguished as between inputs into production and elements of final demand. To somewhat account for imports of primary materials which do bear importantly upon the supply potential of the economy, we have added to our materials input proxy variable key imported materials which enter the producer goods sector. These are mainly energy and metallic ores. We think this somewhat compensates for a deficiency in GNP accounting which can be illustrated in the case of crude oil. Theoretically, changes in the costs and returns of domestic crude production are captured in GNP and the GNP deflator, since the value added in the mining sector is measured. Also, if there are no differences in the measurement of prices of imports and prices of final demands, and no lags between time of import and time of final consumption, then a change in price of imported crude oil will not affect the GNP deflator, by definition. In reality, domestic oil processors mix imported and domestic crude oil to achieve desire technical characteristics; prices of petroleum products are a function of the input price mix, and the domestic price cannot be determined independently of the cost of foreign oil. The value added concept would indicate that it can be. Hence by adding key imported raw materials and their prices into total input, supply price is represented more realistically.

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COMMENTS ON ESTIMATING POTENTIAL OUTPUT FOR THE U.S. ECONOMY IN A MODEL FRAMEWORK

By GEORGE M. VON FURSTENBERG, *American Enterprise Institute*

The paper by Albert Eckstein and Dale Heien greatly broadens the range of factors that may be considered in estimating potential output but it is not clear that this necessarily improves the reliability of the resulting estimates. Processing through a supply-constrained macroeconomic model, the authors have derived a new set of estimates of the annual percentage output gap. Until 1968 these estimates consistently show a somewhat larger gap than the official series published prior to the 1975 benchmark revisions. However, the average annual growth rates of potential output between full-employment years such as 1953 and 1968 are almost identical. After 1968 Eckstein-Heien (EH) estimate much larger gaps.

Part of the difference can be explained by the exclusion of the farm and general government sectors from the EH estimates. Because the gross products originating in these sectors are cyclically insensitive, the percentage gap is widened by excluding them from the estimates of both actual and potential output. Furthermore, the growing importance of these sectors in recent years may have caused part of the increasing divergence between the official and the EH estimates shown in Table 1.

TABLE 1.—ALTERNATIVE ESTIMATES OF THE OUTPUT GAP IN PERCENT OF POTENTIAL GNP [1]

	Past official estimates	Eckstein-Heien estimates	Difference
1952	0.2	−0.4	0.6
1953	−.8	−0	−.8
1954	4.0	5.0	−1.0
1955	.2	.3	−.1
1956	1.8	1.6	.2
1957	3.7	4.0	−.3
1958	8.0	8.8	−.8
1959	5.5	5.6	−.1
1960	6.4	6.9	−.5
1961	7.8	8.5	−.7
1962	5.1	5.3	−.2
1963	4.8	5.1	−.3
1964	3.2	3.3	−.1
1965	.8	1.4	−.6
1966	−1.7	−1.2	−.5
1967	−.3	.4	−.7
1968	−1.0	−.3	−.7
1969	.3	1.6	−1.3
1970	4.6	6.0	−1.4
1971	5.2	7.3	−2.1
1972	3.2	5.2	−2.0
1973	1.5	3.4	−1.9
1974	7.3	9.6	−2.3
1975	[2] 13.7	15.1	−1.4

[1] EH use the potential gross private nonfarm product as referent.
[2] Based on data for the 1st 3 quarters of 1975 reported prior to the benchmark revisions.

Source of official estimates: U.S. Department of Commerce, "Business Conditions Digest," January 1975, p. 109, and December 1975, p. 95.

In deriving the past official series last published in the December 1975 issue of Business Conditions Digest the Council of Economic Advisers assumed that output per manhour grew by 2.5 percent and potential output by 4.0 percent per annum from the fourth quarter of 1969 to the third quarter of 1975. It has since become apparent that these estimates may have been too high for the most recent years.[1] However, after detailed consideration of the changed energy and materials supply factors, EH still find higher growth rates of potential output over this period than are reflected in the past official series. The counterintuitive result of more than 4 percent potential growth even from 1974 to 1975 is at variance with the results of other studies. Roger Brinner has cited several factors supporting his finding that the growth in aggregate factor productivity has recently been declining and that this slowdown will persist into the future.[2] Hence it may well be doubted that the particular specifications and data used by EH to model some of the structural changes of recent years yield results which prove to be robust under alternative specifications or data selections. Unfortunately such sensitivity-testing will not proceed since EH use input data which have already been superseded by the benchmark revisions. These revisions generally had the effect of making the cyclical amplitude of real GNP and its major components less than previously estimated, so that the officially reported gaps have since been reduced.

Data limitations aside, the authors do not fully explain the conceptual basis for their estimates or the uses to which they might be put. While EH set out to improve "our understanding of the economy's potential for absorbing a growing labor force at tolerable rates of inflation" neither the level of potential employment nor its relation or lack of relation to tolerable inflation rates is analyzed. Rather EH accept the traditional four percent unemployment target as the appropriate measure of the economy's potential for labor force utilization and do not investigate the compatibility of such a low unemployment rate with tolerable price stability under present conditions.

If 4 percent unemployment approximately represented the "natural" unemployment rate compatible with non-accelerating inflation in the mid-fifties, there are several reasons why it can no longer have the same meaning. Arguments to this effect, which have centered on changes in the composition of the labor force and the growth of income maintenance programs have been surveyed in the 1975 and 1976 Economic Reports.[3] In recognition of at least some of these factors, variable-unemployment rate estimates of potential output have been provided both in the 1974 Report [4] and in other studies [5] on an exploratory basis.

Potential output estimates have different uses and no single estimate is equally appropriate for all. In some of the most crucial and least political applications, potential output is treated as no more than a cyclically-adjusted measure of output, and the degree of excess

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[1] See the revisions in U.S. Department of Commerce, Business Conditions Digest, April 1976, p. 95.

[2] Roger E. Brinner, "The Growth of Potential GNP," The Data Resources U.S. Long-Term Bulletin, winter 1976, pp. 95–98.

[3] Economic Report of the President, Transmitted to the Congress, February 1975, pp. 94–124, and Economic Report, January 1976, pp. 106–117.

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demand or supply that is held constant in that measure is of no particular significance. The full-employment surplus, for instance, has traditionally been measured with reference to the official estimate of potential output but it has been emphasized that changes in the full-employment surplus, possibly scaled by full-employment GNP, and not the level of that surplus are most relevant for fiscal policy analysis. Similarily, econometric estimates in which potential output gaps have been used to represent changing demand pressures on particular sectors are generally invariant to scalar (multiplicative) transformations of potential GNP. Hence, for these uses, the level of potential output is immaterial provided the percentage changes from any starting level are estimated consistently. In that case potential output serves merely as an analytical tool and not as a norm of performance. By the same token, the usefulness of this tool would be unaffected by anyone showing, for instance, that potential is consistently one percent larger or smaller than officially estimated.

Traditionally, measures of potential output have attempted to hold the degree of labor force utilization constant at some level without explicitly incorporating capacity utilization. This was done in the belief that there can be no permanent mismatch between capital and labor if factor and product prices are free to vary and if resources can shift and be substituted for each other if it is profitable to do so. For in that case similar degrees of excess supply or demand would probably prevail for both major factors of production over a period of years. Both Brinner and Eckstein and Heien attempt to remedy this imprecision by specifying the fixed degree of capacity utilization that is believed to be consistent with 4 percent unemployment. Brinner sets the Federal Reserve Board capacity utilization rate in manufacturing at 87 percent, while EH pick 83 percent at potential. However, the desired degree of capacity utilization is clearly a function of relative factor prices as well as of long-run expectations and it is not clear whether any postulated pair of unemployment and capacity utilization rates that appeared feasible in the past will be any more consistent in the future than past unemployment-inflation trade-offs. Hence, each new argument or factor that is introduced into potential output analysis brings with it the need to impose new constraints on the combinations of variables for which the model is solved at potential.

Elaborate supply-oriented models, such as the one provided by Eckstein and Heien are most valuable for improving our understanding of the structure of the economy. However, they have not hitherto yielded estimates of potential output which are demonstrably more reliable and useful in my view than the existing official estimates. The note to the CEA estimates published in *Business Conditions Digest*, emphasizes that the official estimates are subject to a margin of error. They are also intended to reflect long-term trends rather than annual wobbles. Even though these estimates thus involve a great deal of averaging and recognize only the most durable trends in the growth of productivity, of the labor force, and in average hours worked, there is nothing in the EH paper to suggest that the official series has greatly misrepresented trend movements until 1968. For the 1969–75 period, however, the EH estimate of more than 4.3 percent average annual rates of potential growth is likely to be wider off the mark than the past official estimate of 4 percent.

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